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CHEMICAL MEDIATORS OF AUTONOMIC NERVE IMPULSES[1]

By Professor WALTER B. CANNON

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THE foremost physiologists of the world have given years of their professional activity to research on the contraction of skeletal muscle. Its more humble cousin, smooth muscle, which thrusts us into the world, and which for decades supports by its services our nutritive functions and our conscious existence, has had relatively little attention. The slow action of smooth muscle, its peculiar innervation, its special responsiveness to humoral agents and to certain drugs render it an especially convenient and promising agency for physiological analysis. And the results obtained by such analysis may have significant bearings on processes elsewhere in the organism—on the nature of stimulation and inhibition, for example, and on the effects of biochemical and pharmacological agents.

[1] Read at the joint meeting of the Federation of American Societies of Experimental Biology at Cincinnati, Wednesday, April 12, 1933.

The autonomic system characteristically innervates smooth muscles and glands. In this paper I propose to direct attention only to smooth and cardiac muscle, and I hope to bring before you observations which have importance for physiologists, biochemists and pharmacologists.

As preliminary to a consideration of the chemical mediators of autonomic nerve impulses it is well to learn what is known regarding autonomic nerve endings. During the past 60 years some histologists have represented nerve filaments as actually penetrating smooth muscle cells; their testimony, however, has not been accepted because of untrustworthy technique and also because other competent histologists described endings on the cell surface. To Boeke[2] is credited the first reliable evidence that the nerve twig enters the muscle fiber and ends there in a fine

[2] J. Boeke, *Verhandel. d. Koninkl. Akad. v. Wetensch.*, Amsterdam, xxiii: 1416, 1915.

reticulum, often close to the nucleus. Boeke's studies were made on the ciliary muscle of the human eye. His observations were confirmed by Stöhr[3] in a study of the neuromuscular elements of the human urinary bladder, by Lawrentjew[4] and by Hill[5] in the intracytoplasmic nerve endings in the contractile cells of the bladder, stomach and intestine. Lawrentjew has figured instances of depression in the nucleus in which the terminal nerve net is present and other instances of partial or complete encircling of the nuclear body by the nerve filament. The fact appears to be well established that nerve impulses are not merely brought to the surface of smooth-muscle cells, but are delivered to the interior, in the region of the nucleus.[6]

Another point of considerable interest is the failure of histologists to find two distinct neurone endings in the same muscular element. Since there are areas of smooth muscle, such as those of the intestinal wall, which are under more or less antagonistic sympathetic and parasympathetic control, we might expect to find representatives of these two divisions of the autonomic system present, at least occasionally, in single cells. I have not been able to discover, however, any evidence in support of that arrangement. The alternative mode of organization would be the supply of sympathetic fibers to some muscle cells and of parasympathetic fibers to others.

A third significant fact reported by histologists is their inability to find nerve filaments distributed to all smooth-muscle cells. Since 1850 nearly a dozen investigators have reported that not every cell receives a nerve ending. This negative testimony might be attributed to defects of technique. Recently, however, Stöhr[7] has reported that he has examined large numbers of preparations most carefully and, finding a lower ratio than one cell in a hundred with a nerve supply, he has declared that he will not believe in the dependence of each muscular unit on direct nervous control until there is clear proof to the contrary. In the ciliary muscle of the eye, however, Boeke[6] described, last year, the presence of so rich a display of nerve terminals in the contractile mass that he infers the possibility that every fiber received a nerve ending. He suggests that the meagerness of innervation, previously found in other smooth-muscle structures, is explicable in the difficulties of staining. At present, therefore, the question must remain open.

If there is not a detailed one-to-one relation between nerve ending and smooth-muscle cell the impulse delivered to the special innervated cell might be effective on neighboring common cells by either a physical or a chemical agency of transmission. The view that smooth muscle is a syncytium, with the elements united by protoplasmic bridges, has been both affirmed and denied.[8,9] Whether bridges are present or not, we now have evidence that a chemical agency set free by nervous influence in muscle cells in one region can affect other, remotely situated muscle cells which have been completely deprived of their autonomic innervation. The requirement of an individual nerve supply for each contractile fiber is thereby rendered unnecessary.

That autonomic nerve impulses liberate chemical substances in muscle was first shown by Loewi[9a] in 1921. As is well known, he then reported that Ringer solution resting in contact with a frog heart which has been checked by vagal stimulation is given a new property, that of being able to induce in another heart the typical vagal effects. And when the cardio-accelerator nerves are stimulated the solution is endowed with typical sympathomimetic properties. Although these observations have failed to be confirmed by such competent investigators as Asher[10] and E. and P. Gley,[11] others, notably Plattner,[12] Kahn,[13] Samoiloff[14] and Bain,[15] have brought confirmation of Loewi's experiments (for reviews see H. Frédéricq,[16] and Demoor[17]). By perfusing with dilute defibrinated blood the cat or rabbit heart, while stimulating its nerves, Rylant[18] was able to reproduce in warm-blooded animals the effects obtained by Loewi and others on the frog and tortoise. The evidence supporting Loewi's testimony seems now to be conclusively favorable.

Substances mimicking the action of vagal nerve impulses are not only given off from the heart but also from other structures. For example, Engelhart[18a] has

[3] Ph. Stöhr, Jr., *Zeitschr. f. Anat. u. Entwicklungsgesch.*, lxxviii: 555, 1926.

[4] B. J. Lawrentjew, *Zeitschr. f. mik.-anat. Forsch.*, vi: 467, 1926.

[5] C. A. Hill, *Phil. Trans. Roy. Soc.*, London, B ccxv: 355, 1927.

[6] Cf. J. Boeke, *Jour. Comp. Neurol.*, lvi: 27, 1932.

[7] Ph. Stöhr, Jr., "Mik. Anat. d. Veg. Nerv. Syst.," Berlin, p. 107, 1928.

[8] C. McGill, *Am. Jour. Anat.*, ix: 493, 1909.

[9] O. W. Tiegs, *Austr. Jour. Exp. Biol. and Med. Sci.*, i: 131, 1924.

[9a] O. Loewi, *Arch. f. d. ges. Physiol.*, clxxxix: 239, 1921. Also cxciii, 201, 1922.

[10] L. Asher, *Arch. f. d. ges. Physiol.*, cxciii: 84, 1922. Also *ibid.*, 1925, ccx, 689. *Zeitschr. f. Biol.*, lxxviii: 297, 1923.

[11] E. Gley and P. Gley, *C. r. Soc. de Biol.*, xciv: 269, 1926.

[12] F. Plattner, *Zeitschr. f. Biol.*, lxxxiii: 544, 1925.

[13] R. H. Kahn, *Arch. f. d. ges. Physiol.*, ccxiv: 482, 1926.

[14] A. Samoiloff, *Arch. f. d. ges. Physiol.*, ccxvii: 582, 1927.

[15] W. A. Bain, *Quart. Jour. Exper. Physiol.*, xxii: 269, 1932.

[16] H. Frédéricq, *C. r. Soc. de Biol.*, xcvii: Réunion plénière, May 27–28, 1927.

[17] J. Demoor, *Ann. de Physiol. et de Phys.-Chem. Biol.*, v: 58, 1929.

[18] P. Rylant, *C. r. Soc. de Biol.*, xcvi: 1054, 1927.

[18a] E. Engelhart, *Arch. f. d. ges. Physiol.*, ccxxvii: 220, 1931.

found that after the smooth muscle of the ciliary body and the iris has been contracted by oculomotor stimulation, the aqueous humor exhibits a new, markedly inhibitory action on the tortoise heart. Furthermore, Bain (1932) has reported that fluid flowing through vessels of the tongue, while the smooth muscle of the walls was being relaxed by stimulation of the lingual nerve, acquires properties which make it excitatory to the muscle of the rabbit intestine. And finally Gibbs and Szelöczey[19] have demonstrated, by perfusing the cat submaxillary gland during periods of electrical excitation of the chorda tympani, that the Ringer solution which has passed through the vessels can cause fall of blood pressure, excitation of salivary flow, inhibition of the isolated frog heart and augmented activity of the isolated intestine. All these experiments, consistent in showing that a parasympathomimetic substance is given off when various cranial autonomic nerves are excited, indicate that the term "vagus substance," proposed by Loewi, is not sufficiently broad. "Parasympathin" would be a more inclusive term, shorter than "parasympathicusstoff" suggested by Engelhart (1931).

In 1929 Demoor cast doubt on the idea that in natural conditions autonomic nerve impulses cause liberation of substances mimetic of nerve impulses. The artificial irrigation of the heart, he declared, might create new conditions for the tissues, accompanied by an unphysiological permeability of cell membranes and a consequent abnormal escape of chemical agents having vagal or sympathetic effects. So far as the so-called "chorda substance" is concerned, Demoor's skepticism has been effectively countered by the experiments of Babkin, Gibbs and Wolff,[20] unless objection can be raised to their use of physostigmine. They have been able to obtain a clear fall of blood pressure, and also a secretion of saliva from the opposite denervated submaxillary gland (*cf.* Babkin, Alley and Stravraky[21]) on stimulating the chorda tympani, while the blood was normally circulating.

There is good evidence, likewise, that the sympathetic substance is released from excited cells under physiological conditions. To be sure, the experiments of Brinkman and Van Dam,[22] Lanz[23] and Külz,[24] showing that a substance from the nervously accelerated heart has a sympathomimetic inhibitory action on gastric peristalsis, and also the experiment of Finkelman demonstrating a chemical transfer of inhibitory action from a nervously inhibited piece of gut to another, denervated piece, were performed with salt solution as a vehicle. In these instances, therefore, Demoor's criticism might be pertinent. The experiments of Newton, Zwemer and Cannon,[25] of Cannon and Bacq[26] and of Rosenblueth and Cannon[27] have proved, however, that the heart, the salivary gland and the nictitating membrane, deprived of sympathetic innervation, exhibit responses characteristic of sympathetic influence when smooth muscle of remote regions is stimulated by way of sympathetic nerves, and when the only communication is through the blood stream. The evidence seems quite clear that not only are sympathomimetic and parasympathomimetic substances produced when smooth or cardiac muscle is stimulated by corresponding nerves, but that these substances diffuse out from the affected organs into the circulating blood and under appropriate conditions can have typical mimetic effects on distant organs.

What is the nature of these substances? Examination of the vagus substance has shown that it is dialyzable, that it is stable in an acid but not in an alkaline medium, and that it is rapidly destroyed by a blood or tissue esterase.[28,29] In general it appears to be a highly labile and very active ester of choline and possibly acetylcholine itself. The vagus substance and acetylcholine both act the same on the frog heart, both are very sensitive to substances in minced organs and in blood, the destruction of both by cellular extracts is checked by physostigmine, and if the vagus substance has been rendered inactive by such extracts it can be restored by acetylization.[30]

The chorda substance likewise resembles acetylcholine. The two have the same effects on blood pressure, salivary secretion, cardiac rate and intestinal rhythm. Both are destroyed by blood, and this destruction can be prevented by physostigmine. In one respect, in the experience of Gibbs and Szelöczey (1932), do the two differ—the chorda substance when biologically assayed is sometimes not so quickly destroyed in blood as is acetylcholine. They state that otherwise they have not been able to find any difference between the two substances.

Until a few months ago the evidence was fairly con-

[19] O. S. Gibbs and J. Szelöczey, *Arch. f. exper. Pathol. u. Pharmakol.*, clxviii: 64, 1932.

[20] B. P. Babkin, O. S. Gibbs and H. G. Wolff, *Arch. f. exper. Pathol. u. Pharmakol.*, clxviii: 32, 1932.

[21] B. P. Babkin, A. Alley and G. W. Stravraky, *Trans. Roy. Soc. Canada*, Sec. v, 89, 1932.

[22] R. Brinkman and E. Van Dam, *Arch. f. d. ges. Physiol.*, cxcvi: 66, 1922.

[23] A. B. Lanz, *Arch. néerl. de Physiol.*, xiii: 423, 1928.

[24] F. Külz, *Arch. f. exper. Pathol. u. Pharmakol.*, cxxxiv: 252, 1928.

[25] H. F. Newton, R. L. Zwemer and W. B. Cannon, *Am. Jour. Physiol.*, xcvi: 377, 1931.

[26] W. B. Cannon and Z. M. Bacq, *ibid.*, xcvi: 392, 1931.

[27] A. Rosenblueth and W. B. Cannon, *ibid.*, xcix: 398, 1932.

[28] W. R. Witanowsky, *Arch. f. d. ges. Physiol.*, ccviii: 694, 1925.

[29] O. Loewi and E. Navratil, *ibid.*, ccxiv: 678, 689, 1926.

[30] E. Engelhart and O. Loewi, *Arch. f. exper. Pathol. u. Pharmakol.*, cl: 1, 1930.

sistent that the substance set free from the heart on sympathetic stimulation is adrenin. It is not an inorganic salt (of potassium, *e.g.*), for it disappears when the cardiac contents are ashed. Like adrenin it is rendered inactive when mixed with eosin and exposed to ultra-violet light (Loewi and Navratil, 1926). The substance derived from smooth muscle has similar properties. Like adrenin, it causes, when conveyed by the blood stream, not only acceleration of the heart, but rise of blood pressure, flow of saliva (in the cat), contraction of the nictitating membrane, the spleen and the pregnant uterus (cat) (Cannon and Bacq, 1931; Rosenblueth and Cannon, 1932). And like adrenin it has its influence increased by a previous injection of cocaine.[31] Despite the resemblances to adrenin, Cannon and Bacq (1931) suggested that the substance derived from smooth muscle when affected by sympathetic impulses be given a special name, "sympathin." Recent experiments by Cannon and Rosenblueth[32] indicate not only that sympathin is different from adrenin, but that there are two kinds of sympathin.

The evidence that sympathin differs from adrenin is found in the difference in the effects of the two substances after ergotoxine. Whereas, under this condition, adrenin causes a pure *fall* of blood pressure, stimulation of the lower abdominal sympathetic chains causes, after an initial slight fall, a prolonged rise; and hepatic nerve stimulation causes a pure *rise*. Both substances, sympathin and adrenin, produce acceleration of the heart; if a dose of adrenin is given, exactly matching the effect of sympathin on the heart, the results on blood pressure are quite opposite in character—the difference, therefore, is attributable to influences on peripheral structures.

Dale[33] has shown that ergotoxine abolishes the action of adrenin on sympathetic vasoconstrictor fibers while leaving vasodilator fibers unaffected. The difference between the actions of adrenin and sympathin, therefore, might be due to different relations to vasodilator systems, *i.e.*, adrenin might affect vasodilators and sympathin might not. This was proved to be true in two ways. Whereas before ergotoxine, sympathin and a moderate dose of adrenin cause contraction of leg volumes, after ergotoxine the *rise* of arterial pressure from sympathin is attended by slight, probably passive, expansion of leg volume, while the *fall* of pressure from adrenin is attended by a marked expansion (*i.e.*, vascular relaxation). Furthermore, if with no ergotoxine, a minimal dose of adrenin is injected into a vein, it induces contraction of the denervated nictitating membrane and an expansion of the volume of the denervated leg; on the other hand, sympathin from the liver region, inducing a similar contraction of the membrane, causes a striking contraction of leg volume. In short, adrenin can induce both contraction and relaxation of smooth muscle, and sympathin, in the experiments mentioned thus far, is shown to induce only contraction.

The question arises, then, is sympathin actually incapable of causing relaxation? To answer this question observations were made on the denervated nictitating membrane as an organ *contracted* by adrenin, and on the denervated non-pregnant cat uterus as an organ *inhibited* by adrenin. When now the nerves to the liver are stimulated the nictitating membrane contracts, but the uterus makes no response. It will be recalled that such stimulation causes, after ergotoxine, a pure rise of blood pressure, as if it has only *contractile* effects. Stimulation of the splanchnic nerves not only has contractile effects, on the blood vessels of the splanchnic area, but also inhibitory effects, on the smooth muscle of the gastro-intestinal tract. The interesting fact then appeared that if the splanchnic nerves are excited not only does the nictitating membrane contract, but the uterus relaxes. We do not know any region in the body where sympathetic impulses bring about pure relaxation—blood vessels are present which contract. The nerves on the duodeno-hepatic artery, however, are distributed to the liver, where they contract smooth muscle, and to the intestine, where they relax it. When these nerves are stimulated the same effects are seen as when the splanchnics are stimulated —the nictitating membrane contracts, the uterus relaxes. Now if the nerves to the intestine are severed, the same stimulation as before induces only contraction of the nictitating membrane.

From these experiments Cannon and Rosenblueth have concluded that there are two kinds of sympathin —sympathin E, given off from smooth muscle which is excited to contract by sympathetic impulses, and sympathin I, from smooth muscle inhibited by those impulses. Escaping from the cells of origin, sympathin E is carried in the blood stream and is capable of causing contraction in distant smooth-muscle organs which contract in response to sympathetic influences; and sympathin I, analogously, affects smooth-muscle organs which relax.

In an analysis of the hyperbolic curves resulting from the effects on contracted or inhibited smooth muscle, when increasing doses of adrenalin are injected, Rosenblueth[34] was led to infer that a chemical reaction takes place in the cell between the adrenalin

[31] A. Rosenblueth and T. Schlossberg, *Am. Jour. Physiol.*, xcvii: 365, 1931.

[32] W. B. Cannon and A. Rosenblueth, *Am. Jour. Physiol.* (in press), 1933.

[33] H. H. Dale, *Am. Jour. Physiol.*, xxxiv: 176, 1906.

[34] A. Rosenblueth, *Am. Jour. Physiol.*, ci: 149, 1932a.

(A) which enters and a hypothetical substance H, and that the degree of change depends on the amount of AH formed. Because the curves resulting from increasing frequencies of maximal stimuli applied to the sympathetic nerves of the same smooth-muscle organs were identical in character (*i.e.,* rectangular hyperbolas), Rosenblueth[34a] drew the inference that the nerve impulses set free in the cells a mediator (M) which unites with the substance H and affects the responsive agent as AH affects it. In this concept M would be the same as A, and therefore adrenalin would have the same action as sympathetic stimulation.

The experiments just reported require, we believe, the separation of H into two distinct substances, E and I. ME then becomes sympathin E; and MI, sympathin I.

Whether the conclusions derived from stimulation of motor and inhibitory sympathetic nerves can be transferred analogously to motor and inhibitory parasympathetic nerves is questionable. When the chorda tympani is stimulated (Gibbs and Szelöczey, 1932) the perfusing fluid has *inhibitory* effects on the heart and *excitatory* effects on the intestine—a double action which in this case might be expected because of double action of the nerve impulses on submaxillary blood vessels and gland cells. But in the experiments of Engelhart (1931) oculomotor impulses caused *contraction* of the rabbit's ciliary muscle, whereas the substance diffusing into the aqueous humor induced *inhibition* of the tortoise heart. A similar discrepancy occurred in Bain's (1932) experiments on the fluid perfused through the vessels *inhibited* by stimulation of the lingual nerve in the dog; the fluid made the muscles of the rabbit intestine *contract.* In all these experiments, it should be noted, the active substance was obtained by running salt solution through the organs or by adding it to an extract. The substance acetylcholine is well known to be highly unstable. Conceivably any modification of the "vagal substance," for excitation and for inhibition, would not retain its differential feature under such treatment. Or the transfer of vagus stuff from one species of animal to another, as in two of the experiments cited, might be too unphysiological to permit natural results. Or the differential feature might be so closely attached to the reacting mechanism of the cell that it is not free to migrate with the substance which is common to various parasympathetic impulses. Even though the parasympathetic mediator, however, should prove to act differently from the sympathetic mediator, with respect to excitation and inhibition, that would not invalidate the evidence in hand that two types of sympathin exist—in the E and I forms.

[34a] *Am. Jour. Physiol.,* cii: 12, 1932b.

These considerations have interesting bearings on the views expressed by Langley[35] regarding the action of sympathomimetic and parasympathomimetic drugs. He assumed a chemical combination between adrenin, for example, and receptive substances in responding cells. These substances were supposed to belong to two classes—contractile and inhibitory. Langley's receptive substances in smooth muscle would correspond to the substances E and I, here postulated. He did not develop his views with regard to the transmission of nerve impulses—indeed, he did not assume that the impulses evoke locally an adrenin-like substance, as Elliott[36] did. That such a substance is produced when sympathetic impulses influence smooth muscle is indicated (1) by the identity of the curves correlating the responses of smooth muscle with increasing quantities of adrenin and nerve stimulation, (2) by the similarity of the effects of sympathin E and I to the effects of adrenin, and (3) by the similarity of the chemical reaction of sympathin to the reaction of adrenin.[36a] In this view the differences between Langley and Elliott are reconciled and Langley's idea of receptive substances for adrenin is extended to the operation of sympathetic nerve impulses.

The considerations just outlined bear upon a question which has been raised by Parker[37] regarding the source, in muscle cells or nerve terminals, of the neuromimetic humoral agents. The chemical substances which influence chromatophores are of nervous origin—from the eye stalk in the shrimp, and from structures of neural origin, the adrenal medulla and the posterior lobe of the pituitary, in lower vertebrates. Parker has suggested, therefore, that the substance which acts when nerve impulses arrive at an effector cell is a *secretion of the nerve terminals,* and therefore not a derivative of the cell itself. If the nerve twigs distributed to smooth muscle end inside the cell, as the histologists state, a secretion from these minute twigs could not directly enter the blood and thus influence distant organs, but would first mingle with the fluids of the cell. In that case the escaping humoral agent would certainly be in part of muscular origin. Rosenblueth's evidence, that before the responsive mechanism of the cell is affected a chemical union of two substances occurs, is further testimony in favor of a factor provided by the reacting cell. And finally the special character of the substance from contracted and from inhibited cells, sympathin E and I respectively, clearly points to an origin in the muscle cells which respond differently and not in the undifferentiated sympathetic impulses.

[35] J. N. Langley, *Jour. Physiol.,* xxxiii: 374, 1905.
[36] T. R. Elliott, *Jour. Physiol.,* xxxi: p. xx, 1904.
[36a] Z. M. Bacq, *C. r. Soc. de Biol.,* cvii: 1584, 1931.
[37] G. H. Parker, "Humoral Agents in Nervous Activity," p. 55, Cambridge, 1932.

The intermediation of a chemical agent between the nerve and the responsive mechanism in smooth muscle requires, as Loewi[38] has noted, a readjustment of our ideas regarding the mode of action of certain drugs. Atropine, for example, does not paralyze vagal endings in the heart; when the vagi of an atropinized heart are stimulated, quite as much vagus substance is produced as if the heart were not atropinized. The effect of atropine, therefore, is not to prevent the passage of vagal impulses, but to prevent the vagus substance from influencing the responsive mechanism of the cell. Similarly, Cannon and Bacq (1931) found that a dose of ergotoxine which abolished any obvious contraction of the pilomotors did not prevent the production of sympathin E; for the heart was accelerated, by sympathetic stimulation of the pilomotors, quite as much after ergotoxine as before. Again, as Loewi[38] has pointed out, it is commonly supposed that physostigmine sensitizes the heart to vagus stimulation; experiment proves, however, that physostigmine is not directly concerned with vagal impulses, but augments and prolongs the influence of the vagus substance. With increase of knowledge of the rôle of chemical mediators of nerve impulses probably other occasions for modifying ideas of pharmacological action will arise.

The evidence for the existence of two substances, sympathin E and I, resembling adrenin in action but differing from it in discriminative relations to excitatory and inhibitory effects, suggests the possibility of so modifying adrenin by chemical means that it too might be used in a discriminative manner. Thus adrenin E, if made, could be used to stimulate the heart, raise blood pressure, etc., without inhibiting the digestive process. And adrenin I could be employed to relax spasm of the intestine or bronchioles, for example, without raising arterial pressure or increasing blood sugar. Such possibilities render important the attempt to obtain modified forms of adrenin.

[38] O. Loewi, *Internat. ärztl. Fortbildungskursus*, xii: 325, 1931.

HIGH VOLTAGE. II

By Dr. KARL T. COMPTON

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AFTER this historic survey of electrostatic generators, let me now return to the text of my address, "Necessity is the Mother of Invention." Until very recently there was no compelling need to force physicists to seek ever higher and higher voltages in electrical-generating devices. Their needs were met by existing devices of the electromagnetic type. Within the past dozen years, however, it has become evident that a whole new range of fundamental investigation into the properties of atoms will be opened up by a suitable source of high potentials.

This new inducement may be said to have arisen with Rutherford's discovery that it is possible to transmute one chemical element into another by bombarding it by the fast electrified particles known as alpha particles, which are spontaneously given off by radioactive materials in the process of their disintegration. These brilliant experiments opened up a whole range of new explorations into the structure of the atomic nucleus, and stimulated the imagination of scientists in regard to what might be done if only they had available some more powerful and better controllable source of high-speed missiles to shoot at the atomic nuclei. The alpha particles from radium do have tremendous velocities, but they are relatively few in number and all the radium that could conceivably be gathered together in the world would not produce a stream of electrified particles comparable to that which can be obtained in an ordinary discharge of electricity through a vacuum tube. If only the voltage as applied to a vacuum tube could be made high enough to give the ions in a vacuum tube speeds comparable with or even exceeding those of alpha particles from radium, what a powerful attack could be made upon the nucleus! Not only could particles in billion-fold larger numbers be used, but different kinds of particles could be tried, such as hydrogen-nuclei, helium-nuclei, lithium-nuclei, neon-nuclei and so forth, and these could be given any desired speed up to the maximum limit determined by the highest voltage available. So for the past dozen years, thoughts of scientists have again been turned to means for producing ever and ever higher voltages.

It was to this end that the million-volt installation at the California Institute of Technology was designed. It was also to this end that a system of high potential transformers and condensers was built by Cockcroft and Walton in Cambridge, with which they were the first successfully to disintegrate atoms by means of electrified particles produced from an artificial source and speeded up by an applied voltage. However, the necessities of the case have led to other suggestions for securing high voltages because the inherent limitations of electromagnetic induction devices lead to prohibitive expense and complexity if voltages much above a million volts are sought by such means.

There have thus been three very interesting new developments in the art of securing high voltages, or perhaps more generally, electrified particles with those speeds which would be acquired with tremendously high voltages. Of these, in order of apparent utility, are the devices of Brasch and Lange in Germany, of Lawrence at the University of California and of Van de Graaff at the Massachusetts Institute of Technology.

The greatest natural source of high voltage of which we have any knowledge is the thunderstorm. It is estimated that the voltages in lightning flashes frequently exceed a billion volts; consequently it was natural for Brasch and Lange to look to the lightning flash as a source of high potential and to set up what may be considered as a glorified Franklin kite. Their apparatus consisted of a pair of long cables suspended between mountain peaks in that region of the Alps where thunderstorms are most frequent. These cables may be thought of as huge wireless antennae for receiving the electrical impulses of nearby lightning flashes. This was an installation of real engineering proportions, since the porcelain insulators alone at each end of the cable weighed upwards of two tons. The terminals of the two conducting cables consisted of large spheres, whose distance apart could be varied by drawing in or letting out cable. The voltage obtained was estimated by the sparking distance between these spheres, and voltages were obtained ranging between eight and fifteen million volts.

Although the voltage was tremendously high, its erratic occurrence and uncontrollable nature has led Brasch and Lange to give it up in favor of somewhat more conventional means of producing their high voltage, and at present they are working with an impulse generator.

An extremely clever device is that invented by Professor Ernest Lawrence, of the University of California, by means of which electrified particles may be given energy characteristic of several millions of volts with the application of a much smaller voltage. The principle is that of repeated impulses, analogous to the way by which the amplitude of swing of a child in a swing may be made very great by a succession of small pushes, properly timed. In Lawrence's apparatus, an oscillating voltage is applied to the ions, first in one direction and then in the other, while they are moving in approximately circular paths in a magnetic field and conditions are adjusted so that every time the voltage is applied the ions are speeded up by just that amount. Thus, by applying only a few thousand volts, protons have been obtained with energy corresponding to nearly two and a half million volts.

Fig. 4 shows a diagram of the apparatus. The protons or other ions are liberated, by a suitable device, near the center of a flat hollow cylinder which is divided into two parts separated from each other. The oscillating high frequency voltage is applied to these two parts, and at the same time the whole cylinder is placed between the poles of a powerful magnet. An ion starting at *a* is pulled by the momentary electric field across the gap, and it takes, in the magnetic field, a circular path around to *b*. The frequency is adjusted so that by the time it reaches *b* the direction of the voltage has reversed so that the ion is again speeded up as it crosses *b* back into the half-cylinder from which it started. Then by the time it reaches *c* the voltage has again reversed to its original direction and it is given another push, and so on and so on. The few-thousand-volts push is given to the ion every time it crosses the gap. It proceeds in ever-widening circles, attaining a speed limited only by the dimensions of the apparatus. With this device, Lawrence and his colleagues have reason for hoping that the speeds may ultimately be increased to perhaps the equivalent of ten million volts.

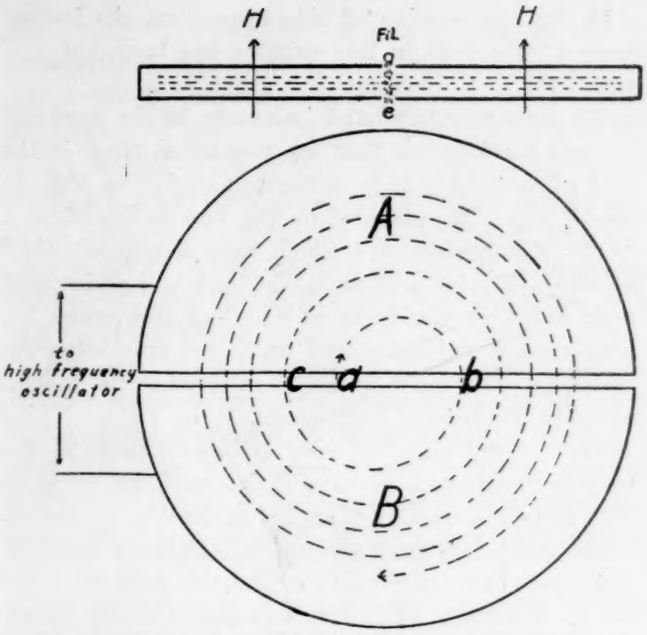

FIG. 4. Diagram of Professor Lawrence's apparatus for producing high-speed, electrified particles

The currents are not very large, being reported of the order of a thousandth of a microampere. Nevertheless, these currents are tremendous in comparison with anything which can be obtained from radioactive material and this source of high-speed, electrified particles will evidently be an important tool in nuclear investigation, as is in fact evident from very recent reports from Professor Lawrence's laboratory, in which the experiments of Cockcroft and Walton in disintegrating lithium nuclei by means of high speed protons have been confirmed and extended.

In the construction of this apparatus, the largest magnet ever built in this country has been put into use.

We come now to what I believe to be the most important development that has ever taken place in the field of extremely high voltages, namely the Van de Graaff generator, invented by Dr. Van de Graaff, as a result of considerations which were developed while he was a Rhodes scholar in England and which first took shape in the form of physical laboratory experiments at Princeton and which are now being developed and extended in the laboratories of the Massachusetts Institute of Technology.

From every point of view it is advantageous for very high voltages to have direct uniform currents. Van de Graaff was therefore led to develop an electrostatic generator, since electrostatic methods yield directly a steady unidirectional voltage such as is desired. Maximum simplicity was sought in the design. The simplest terminal assembly appeared to be a sphere mounted on an insulating column. Since the sphere must be charged and since the process should be continuous, the charge carrier should approach the sphere, enter it and, after depositing its charge inside, should return parallel to its path of approach. This immediately suggested the action of a belt, a device long used for the transmission of mechanical power.

The logic of the situation therefore pointed directly to a generator consisting of a hollow spherical conducting terminal supported on an insulating column, a moving belt to carry electric charge to the sphere, a device for depositing the charge onto the belt in a region of low potential remote from the sphere, and a device for removing this charge from the belt inside the sphere and transferring it to the sphere. A refinement of these essentials was the addition of an induction device whereby charge of the opposite sign was carried by the belt on its return journey, thus doubling the current output. A second refinement consisted of a self-exciting charging device whereby the entire generator could be made to operate independently of any external source of electricity. Not only does this device attain the desired result in what appears to be the simplest possible manner, but it is also interesting to note that the energy transformations in its operations are exceedingly simple, consisting only in the transformation of the energy required to drive the belt into work done in separating and transferring electric charge from earth potential to sphere potential. Fig. 5 shows, schematically, the operation of this generator.

By this means electricity is continually conveyed to the spherical terminal, whose potential consequently rises until limited by the breakdown of the insulation of the air in the form of a corona discharge at the surface of the spheres. This breakdown voltage depends on the size of the sphere, being approximately 750,000 volts for a 2-foot sphere and increasing to 5,000,000 volts for a 15-foot sphere. Thus the attainable voltage depends upon the size of the spherical terminal.

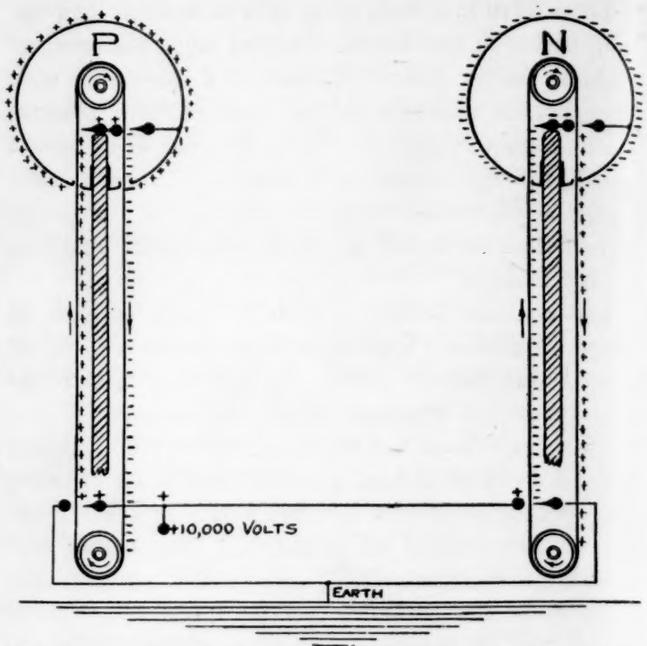

FIG. 5. Schematic diagram of Van de Graaff electrostatic generator

The current, on the other hand, is simply equal to the rate at which electricity is carried to and from the sphere by means of the belts, and this in turn depends upon the size, speed and number of belts and the quantity of electricity which can be placed on unit area of the belt. This latter quantity is also limited by the breakdown voltage of the surrounding air, to an amount of about 5×10^{-9} coulombs per sq. cm. of belt area. Under these conditions it is readily shown that a belt running at 6,000 feet per minute could theoretically carry a maximum current of 150 microamperes per inch width of belt. Actually, the best adjustments have given about half of this theoretical maximum, probably because the breakdown strength of the air is reduced by the mechanism whereby charge is sprayed onto the belts.

Theory and practise also show that these belts may be placed as close together as is geometrically possible, in fact, practically in contact, without interfering with their capacity to carry charge. By packing many belts together it is therefore possible to produce very sizable currents. For example, a small laboratory model for demonstration purposes, constructed this year in the laboratories at Massachusetts Institute of Technology, develops one and one half million volts between a pair of 2-foot spherical terminals, and delivers a current of 900 microamperes carried on two 8-inch belts in each sphere. Even in this small model the currents are approximately a

million times greater than those which have been obtained in the high speed ion source designed by Lawrence.

The first model of such a generator which was actually constructed was built in Princeton in the fall of 1929, being built out of a tin can, a silk ribbon and a small motor, at no expense. This model developed 80,000 volts, being limited by the corona discharge from the edges of the can.

The next model was designed and built for operation in a vacuum tank for reasons to be outlined later.

The third model was built to give a quick and easy demonstration of the possibilities of the machine, using 2-foot spherical terminals supported on pyrex rods, and supplied by current carried on silk belts 2¼ inches wide, driven by small motors. This apparatus was demonstrated successively in Princeton, New York, Washington, Boston and elsewhere. Although built at a total cost of less than $100, it developed more than twice as high a voltage as any direct current generator of which we have knowledge.

Encouraged by the success of this model, plans were immediately made for the construction of as large a generator as seemed practical for operation in air, the limitation being placed by the size of the house in which it must operate. The largest place available was a dock built for a Goodyear dirigible on the estate of Colonel E. H. R. Green at South Dartmouth, Massachusetts, and which Colonel Green kindly put at the disposal of the institute. Ten million volts was selected as the highest voltage which could be used in a building of this size without excessive loss of current through the air to the roof and walls. For this voltage, therefore, there has been built a generator with 15-foot spherical terminals made of welded aluminum, mounted on 24-foot textolite insulating columns in the form of 6-foot cylinders, and carried on large fabricated steel trucks, running on a 14-foot gauge railway track in order to vary the position of the terminals when desired.

In this construction the Research Corporation gave invaluable aid through assistance in the engineering drawings and through a grant of $10,000, which defrayed approximately half the cost of the generator.

In using this generator for experimental purposes it is planned to use the inside of the spheres as laboratory rooms, and to mount the discharge tube, suitably designed for producing high speed ions, between two spheres.

Every feature in the construction and operation of this large generator has gone as expected and a few days ago the first belt was put into operation and voltage generated as expected. This belt is made of paper 3 feet wide and running at about 5,000 feet per minute. The initial trials gave an output of 600 microamperes, and previous experience indicates that with the proper adjustments this output may be increased to a milliampere. The design of the apparatus is such that a large number of belts may be made to operate in parallel, so that there will be no difficulty whatsoever in securing an output of between a tenth and a hundredth of an ampere if such large currents become desirable. It will be noted, however, that if currents as large as a tenth of an ampere are used at 10,000,000 volts, the generator will be delivering 1,000 kilowatts!

The enormous possibilities of this machine become evident when we compare a possible input of 1,000 kilowatts in the form of 10,000,000 volt electrified particles, with the sources which up to the present have been available for experiments on atomic disintegration and which have been principally small amounts of radioactive material.

We come now to a very interesting aspect of this type of generator, namely, the influence of the surrounding insulating medium. If the generator is placed in some medium whose electrical breakdown strength is greater than that of air, then the voltage and the current both increase proportionately and the power output increases as the square of the breakdown strength. The two media most convenient are either some gas such as air at high pressure, or a vacuum. With gas at high pressure, the breakdown strength is approximately proportional to the pressure, so that the operation of a generator in a tank of gas at 30 atmospheres pressure should give 30 times the voltage, 30 times the current and 900 times the power of the same device mounted in the open air. It is relatively easy to build a container for compressed gases and to mount a generator in it, and this, in fact, has been done by Dr. Barton at Princeton, originally with the collaboration of Dr. Van de Graaff.

By far the most intriguing possibilities of this generator are found in its vacuum embodiment, because a high vacuum is the best of all insulators, since it offers no "windage" resistance to the motion of the belt and since many of the applications of the high voltage will themselves go in vacuum discharge tubes which can be built right into the generating system.

Such a generator has been designed and built. It is still in the experimental stage, but various complicating factors have one by one been overcome. Experience to date indicates that there is in sight no insurmountable obstacle to the construction of generators which may even reach considerably higher voltages than the generator at Round Hill.

In conclusion you will be interested to know, if you do not know this already, that two Van de Graaff generators have been built and operated in Washington under the direction of Dr. Merle A. Tuve, of

the Department of Terrestrial Magnetism of the Carnegie Institution. One of these has been actually used for experiments on atomic disintegration and the other instrument, a larger one developing upwards of 2,000,000 volts, is awaiting a suitable housing, now under construction, for its satisfactory operation. Dr. Tuve in Washington, Dr. Coolidge, of the General Electric Company, and Dr. Slack, of the Westinghouse Company, all of whom have built and experimented with Van de Graaff generators subsequent to the demonstration of Van de Graaff's first air-operated instrument in the summer of 1931, have been very helpful in reporting their experiences with the generators.

In conclusion it may fairly be said that this new type of generator as an electrical instrument has already been highly successful and shows promise of very considerable further development. It remains to be seen whether the necessity which was the mother of this invention—namely, the desire for high speed particles for the study of atomic nuclei—will lead to important new knowledge of atomic structure with the aid of this device. Several good men are beginning work on the application of these voltages to nuclear disintegration, and it will not be long before some indications, at any rate, may be obtained as to the significance of the new developments in high voltage technique.

Whether or not the apparatus will be successful in opening up new fields of atomic investigation, it has already opened up the possibility for electrical investigations and possible practical applications of electricity in a new voltage range, and it will be surprising indeed if there are not some developments of scientific and practical significance which will eventually emerge from this new field of activity.

SCIENTIFIC EVENTS

THE EMERGENCY CONSERVATION PROGRAM

IN a statement issued on July 17 Robert Fechner, director of the Emergency Conservation Work, described the work being performed in the 102 camps now in operation. Seventy-four of the President's conservation camps are on state parks in nineteen states; eleven are on county parks in four states; eleven are on metropolitan sections of city park systems, and seven are on miscellaneous federal and state owned areas in two states—all under the supervision of the National Park Service.

In addition to purely forest protection work—and some of the finest forests in America are found in state parks—many miles of foot trails and bridle trails are being constructed; safe water supply and sewage disposal systems are being installed; picnic and camp grounds built and shelter structures erected; small recreation lakes impounded, as well as a great variety of other work that will add immensely to the usefulness of the areas.

The President, early in May, authorized an extensive work program for the state parks and later, by executive order, approved the extension of conservation work to county parks and to metropolitan sections of city parks. In the state parks the types of work authorized are numerous, and are necessary to safeguard the scenic resources of the parks under the heavy use to which most of them are subjected.

Supervision of Emergency Conservation Work in state, county and metropolitan parks was placed with the National Park Service because of the similarity of many of their problems and undertakings with those in the national parks. In addition, the federal agency has maintained close touch with state park developments during the past fourteen years. Until the present, however, there has been no official connection between the National Park Service and the state park authorities. Supervision of these camps, therefore, has required the establishment of a small new field organization.

General direction of park emergency conservation work has been assigned to the branch of planning, National Park Service, headed by Conrad L. Wirth, assistant director. With him as supervisor is Herbert Evison, for the past four and a half years executive secretary of the National Conference on State Parks.

The entire United States has been divided into four districts, under four district officers, each of whom is experienced in state park work. Under their immediate direction is a field force of sixteen inspectors, each in charge of a group of from five to seven camps. These men, of whom all are graduate engineers or landscape architects, help to plan the work and keep in close touch with it through all its stages.

In some states, even where there are extensive and valuable holdings, this is the first time that technically trained men have been available for state park work. In each camp the services of the inspectors are supplemented by four landscape foremen, many of whom are experienced landscape architects. These highly qualified men are charged with responsibility for upholding generally accepted state park standards in the constructive work being performed in the parks.

THE EMERGENCY COMMITTEE IN AID OF DISPLACED GERMAN SCHOLARS

THERE has been formed an Emergency Committee in Aid of Displaced German Scholars, with President Livingston Farrand as *chairman* and Dr. Stephen

Duggan as *secretary*. This committee will be glad to receive contributions, which should be sent to the treasurer, Mr. Fred M. Stein, 2 West 45th Street, New York City. Inquiries should be addressed to Dr. Duggan at the same address.

A statement has been issued by the committee which reads in part:

As a result of the disturbance in Germany many scholars of undoubted merit, some of them among the most distinguished in the world, have been removed from their chairs and must begin life anew with very inadequate means or with no means at all. Many will have to leave the land of their birth and seek opportunity, temporarily at least, in other lands. The situation makes a call not only upon our sympathy, but also upon our resources. In the hope that they may serve their German colleagues in the crisis, we have formed The Emergency Committee in Aid of Displaced German Scholars.

We are, however, aware that as the result of the present economic depression, university revenues in our own country have been sadly reduced and teachers have been dropped from the rolls and are suffering severe deprivation. In such a situation the universities must not be called upon for financial assistance for the benefit of foreign scholars. In most instances the aid to be extended to the latter must come from funds raised from sources outside the universities.

Some such funds have been forthcoming and have been placed at the disposal of the committee, but in view of the number of invitations that the universities would like to extend to the displaced German scholars, the amount is very inadequate. As the displaced scholars are chiefly engaged in research we have informed the universities in which they would probably find working conditions most congenial of our readiness to meet their salaries to the extent and to the number permitted by the resources at our disposal.

We wish to emphasize the emergency nature of our activity. We have not the resources to endow permanent chairs nor in view of the unemployment of our own scholars have we any desire to do so. The funds at our disposal will enable us to cooperate with a university only to the extent of establishing an honorary lectureship to which a German scholar may be invited for a period of one or at the most two years. At the close of such period all commitments on the part of the university and of this committee will cease.

We are aware of the inadequacy of the assistance we are now able to offer. It is in no way a measure of our desire to aid our German colleagues. But it is an earnest of our determination to range ourselves with scholars everywhere in maintaining the traditions of learning that have taken so long to evolve and that are now so seriously threatened. And we rejoice to be able to cooperate in this endeavor with similar committees established in the countries of western and northern Europe.

DISMISSALS FROM THE BUREAU OF MINES

ACCORDING to Science Service, another scientific bureau of the Federal Government suffered on July 15 when an economy edict cut off practically one fourth of the personnel in the U. S. Bureau of Mines.

About 190 to 200 employees received notice that they would be separated from the service on July 15, provided the Civil Service Commission approved. In case the commission failed to act the employees were to be placed upon indefinite furlough at that time. This means that from 25 to 30 per cent. of the present staff of the bureau is being dismissed from the government service. About 70 of these are scientific or technical personnel. Although the separations were effective on July 15, it was stated at the Civil Service Commission that the list had not been received by them on July 13.

The dismissals were made necessary by a drastic reduction in funds. Of the $1,514,300 appropriated by the congress for the Bureau of Mines, $414,300 has been withheld by the Secretary of Commerce, who allotted but $1,100,000 to the bureau for the coming fiscal year. This is a 27.3 per cent. reduction in funds.

All field offices and stations of the bureau are affected by this drastic cut. Some are being abolished entirely; all will have the scope of their activities curtailed. The health division of the bureau is being abolished, and the officers who have been assigned there from the Public Health Service are being returned to the service. The helium division is being merged with the petroleum and natural gas division.

The offices of the bureau have been quietly moved from the new building of the Department of Commerce to the building of the Interior Department. Officials of the bureau said in answer to inquiry, however, that they had not been informed of any actual transfer of the bureau to the Interior Department. In the office of Secretary Roper it was said that the transfer is expected to take place soon.

PUBLIC WORKS FUNDS ALLOTTED TO SCIENTIFIC BUREAUS

OF the $64,561,542 of public works funds recently allotted to governmental agencies, $4,255,592 is distributed to scientific bureaus. Most of the funds will be spent on labor and building material to repair and recondition buildings and laboratories. Some of the allotments are:

Agriculture Department: Bureau of Animal Industry, $549,240 for preserving, repairing, renovating and improving equipment. Bureau of Chemistry and Soils, $33,919 to repair and preserve and equip its various laboratories. Bureau of Dairy Industry, $173,677 for repair work, improvements and installations. Bureau of Entomology, $15,150 for work to prevent loss to agriculture through insects. Experimental Stations, $4,950, for physical repair and improvements for stations in Hawaii and Puerto Rico.

Food and Drug Administration, $70,000 for repairs, painting and reconstruction of physical equipment. Bureau of Plant Industry, $648,806, for repairing, renovating and reconstruction work. Bureau of Plant Quarantine, $63,050 for repairs and improvements, largely to protect the Mexican border from invasion by plant and animal plagues. Weather Bureau, $20,000, for repair work on its stations.

Department of Commerce: Bureau of Aeronautics, $443,000, for relocating and improving air beacons and airway radio facilities. Bureau of Fisheries, $150,000, for reconditioning and repairing hatcheries, buildings and vessels.

Department of the Interior: Geological Survey, $1,200,000, mostly for gauging stream levels. Office of Indian Affairs, $2,820,000, for schools, hospitals and equipment on reservations. National Park Service, $1,250,000, for all parks. Bureau of Reclamation, $44,460,000, for reclamation projects; of this $38,000,000 will go for the Boulder Dam project. Virgin Islands, $114,500, for reconstruction, repair, construction and the building of a leper asylum at St. Croix.

Department of Labor: Bureau of Immigration, $1,344,480, for repairing, altering and improving immigration stations.

State Department: International Boundary Commissions, $1,528,000. This covers work on the northern and Alaskan boundaries, but most is for international flood control works in the lower Rio Grande Valley, contingent on Mexican expenditure.

Treasury Department: Public Health Service, $102,438, largely for reconditioning vessels used for quarantine purposes.

Independent Offices: National Advisory Committee on Aeronautics, $200,000, for experimental work and equipment at Langley Field.

THE INTERNATIONAL GEOLOGICAL CONGRESS

THE sixteenth session of the International Geological Congress meets in Washington from July 22 to July 29. Professor Waldemar Lindgren, of the Massachusetts Institute of Technology, is chairman, and Dr. W. C. Mendenhall, of the U. S. Geological Survey, is secretary of the committee on organization.

A detailed account of the arrangements for the congress will be found in the issue of SCIENCE for March 10. A reception under the auspices of the Geological Society of America is given in New York City on July 21, on which day the American Museum of Natural History gives a luncheon in honor of the foreign guests.

A series of excursions, mostly in the east, has been planned prior to the congress, a series of short excursions is offered during the sessions, and after adjournment there will be extensive excursions to the central and western states. The nature of some of these is indicated by the following summary descriptions of them:

Eastern New York and western New England.
Mining districts of Southeastern and Central States.
Appalachian Valley in Virginia.
Paleozoic stratigraphy of New York.
Coastal plain of the Chesapeake Bay region.
Oil fields of Oklahoma and Texas.
Geomorphology of the central Appalachians.
Mineral deposits of New Jersey and eastern Pennsylvania.
Transcontinental excursion starting from San Francisco.

The following topics have been chosen for consideration:

Measurement of geologic time by any method.
Batholiths and related intrusives.
Zonal relations of metalliferous deposits.
Major divisions of the Paleozoic era.
Geomorphogenic processes in arid regions and their resulting forms and products.
Fossil man and contemporary faunas.
Orogenesis.
Geology of petroleum.
Copper resources of the world.

Papers relating to the topics listed above and others which may be of general interest will be presented at sectional meetings during the session. Owing to the large number of papers already offered, it will be necessary to hold technical sessions on those days for which excursions are planned. In addition to the regular technical program, the centenary of the publication of Lyell's "Principles of Geology" will be observed by an address by Dr. Frank Dawson Adams, of the University of Montreal.

The Geological Society of Washington offers a reception to members of the congress on the evening of July 22. Afternoon tea will be served daily at the Chamber of Commerce Building.

OBITUARY

DR. WILLIAM LEWIS ELKIN, professor emeritus of astronomy at Yale University, where he was director of the observatory from 1896 to 1910, has died at the age of seventy-eight years.

DR. HAROLD DE FOREST ARNOLD, director of research of the Bell Telephone Laboratories, died on July 9. He was forty-nine years old.

FREDERICK WORTHEN BRADLEY, in 1929 president of the Institute of Mining Engineers, died on July 6 at the age of seventy years.

PROFESSOR F. ERIC MILLEN, provincial apiarist and

head of the department of apiculture at the Ontario Agricultural College at Guelph, died on July 14 at the age of fifty years. Dr. Millen was from 1916 to 1919 associate professor of apiculture at the Michigan State College.

Nature reports the deaths of Dr. E. E. Fournier d'Albe, known for his work on the properties of selenium, on June 29, aged sixty-five years; of H. R. A. Mallock, F.R.S., consulting engineer, on June 26, aged eighty-two years, and of Ralph Richardson, formerly president of the Edinburgh Geological Society and secretary of the Royal Scottish Geographical Society, on June 26, aged eighty-eight years.

SCIENTIFIC NOTES AND NEWS

AT a Special Congregation of the University of British Columbia in honor of the Fifth Pacific Science Congress on June 13, the honorary degree of LL.D. was conferred on members as follows: Dr. Charles Gravier, Natural History Museum of Paris; Dr. Geoffrey Ingram Taylor, Yarrow research professor of the Royal Society; Dr. Shinkishi Hatai, professor of zoology, Tohoku Imperial University; Dr. Wen Hao Wong, director of the Geological Survey, Peiping; Dr. Gerrit van Iterson, Jr., professor of microscopical anatomy and director of the Laboratory for Technical Botany, Technical University, Delft; Dr. T. Wayland Vaughan, professor of oceanography and director of the Scripps Institution of Oceanography of the University of California, and Dr. Henry Marshall Tory, president of the National Research Council of Canada and president of the Fifth Pacific Science Congress.

THE University of Michigan at its commencement on June 19 conferred the honorary degree of doctor of science on Dean J. B. Johnston, of the University of Minnesota, in recognition of his contributions to neurology and his work in the field of education.

THE National University of Ireland, Dublin, has conferred the honorary degree of doctor of science on Dr. Dean DeWitt Lewis, professor of surgery, Johns Hopkins University School of Medicine.

THE Philadelphia College of Pharmacy and Science at its one hundred and eleventh commencement conferred the honorary degree of master in pharmacy on Henry K. Mulford, director of biological and research laboratories of the National Drug Company, Philadelphia. Mr. Mulford was the founder and for many years directing head of the H. K. Mulford Company and is now president of the Mulford Colloid Laboratories in addition to his connection with the National Drug Company.

AT the annual meeting of the Board of Trustees of Norwich University, Porter Adams, of Thetford, Vermont, formerly president and now chairman of the Executive Committee of the National Aeronautic Association, was elected vice-president of the university, and at commencement was given the honorary degree of master of science.

DR. WILLIAM J. MAYO, of the Mayo Foundation, Rochester, Minnesota, has been elected a foreign associate member of the faculty of medicine of the University of Paris.

PROFESSOR H. J. MULLER, of the University of Texas, has been elected a foreign member of the Academy of Sciences of the Union of Soviet Socialist Republics at Leningrad.

DR. ALEŠ HRDLIČKA, of the U. S. National Museum, and Dr. Herbert I. Priestley, of the University of California, have been made honorary professors of the National Museum of Mexico.

DR. ROBERT E. COKER, professor of zoology at the University of North Carolina, has been elected president of the university chapter of Sigma Xi.

W. E. WRATHER, consulting geologist, of Dallas, Texas, was elected president of the American Society of Economic Geologists, meeting at Princeton on July 7 and 8. Professor Per Adolf Geijer, of the Swedish Geological Survey, Stockholm, was elected vice-president. Dr. Donald H. McLaughlin, professor of mining engineering at Harvard University, was chosen secretary. The society also elected the following councilors: D. H. Newland, New York state geologist, Albany; Benj. L. Miller, professor of geology at Lehigh University, and Frank W. DeWolf, head of the department of geology of the University of Illinois.

AMONG scientific men from German institutions invited by the Universities Bureau of the British Empire to lecture in the colleges and universities of Great Britain are Dr. Friedrich von Müller, professor of internal medicine, Dr. Jonathan A. W. Zenneck, professor of experimental physics, Dr. Arnold Sommerfeld, professor of theoretical physics, and Dr. Hans Fischer, professor of organic chemistry, all of the University of Munich.

DR. ARTHUR POWELL DAVIS, past president of the American Society of Civil Engineers, has been appointed consulting engineer in the field service of the Bureau of Reclamation, and particularly upon the problems of the Boulder Dam project. Dr. Davis was for years closely associated with the studies and

investigations of the Colorado River Basin which led to the selection of the site where the dam is now being built as the best place to regulate and conserve the flow of the Colorado River. His report is the basis for the construction of the dam. Dr. Davis is a nephew of John Wesley Powell, who first explored the Canyon of the Colorado.

BURNARD S. BIGGS, until recently connected with the research staff investigating petroleum bases in the University of Texas, has been appointed to the faculty of the Carnegie Institute of Technology, Pittsburgh, in the Coal Research Laboratory.

DR. A. RICHARD BLISS, JR., has presented his resignation, effective on August 15, as chief of the division of pharmacology in the University of Tennessee, to accept the position of director of the Research Laboratories of the William A. Webster Company of Memphis.

G. M. J. MACKAY, formerly in charge of the research and development work in the Insulation Section of the General Electric Company Laboratories, has been appointed director of research for the companies in the Cyanamid group of the American Cyanamid Company.

DR. EDWARD MELLANBY, professor of pharmacology at the University of Sheffield, has been appointed Sheild professor of pharmacology in the University of Cambridge.

R. C. EVANS, of Clare College, has been appointed university demonstrator in the department of mineralogy and petrology of the University of Cambridge.

PROFESSOR JOHANNES STARK, formerly professor at Würzburg, has been nominated for the presidency of the Physikalisch-Technischen Reichsanstalt, to succeed Dr. Friedrich Paschen, professor of experimental physics in the University of Berlin.

PROFESSOR HANS EPPINGER, director of the medical clinic at Cologne, has succeeded to the direction of the first medical clinic at Vienna, which had been vacant since the retirement of Professor Wenckebach some years ago.

DR. S. W. RANSON, of Northwestern University Medical School, has received a grant from the Committee on Scientific Research of the American Medical Association for the continuation of his study of the cutaneous nerves in man. The committee has also awarded a grant to Dr. W. R. Tweedy, of Loyola University Medical School, for further studies on the chemical nature of parathyroid hormone.

A GROUP of French scientific men arrived in New York on July 17, to attend the sixteenth International Geological Congress, which will be held in Washington from July 22 to July 29. Among those in the party were Professor Paul Leon Lutaud, of the faculty of sciences of the University of Paris, and Professor Paul Fallot, of the faculty of sciences, University of Lyons. Other foreign geologists reported to be in the United States are Professor O. T. Jones, of the University of Cambridge, Professor E. B. Bailey, of the University of Glasgow, and Professor Pierre Provost, of the University of Lille.

DR. FRANK SCHLESINGER, director of the Yale Observatory, has sailed for Europe, where he plans to spend the summer.

DR. ROBERT L. PENDLETON, chief soil technologist of the National Geological Survey of China, is on leave from the survey and is assuming his regular post as professor of soil technology and head of the department of soils of the College of Agriculture, University of the Philippines.

DR. E. A. BIRGE, president emeritus of the University of Wisconsin, and Dr. Chancey Juday have undertaken a census of fish in the lakes of northern Wisconsin. The headquarters are at Trout Lake in Vilas County. In addition they will direct a study of the growth of plankton and algae. A study will also be made of the large aquatic plants; and experiments in increasing the fish food of various lakes by "planting" fertilizers on the lake bottoms will be continued.

DR. R. E. ROSE, director of the Technical Laboratory of the E. I. du Pont de Nemours and Company, and president of the American Association of Textile Chemists and Colorists, has made a tour of the South, during which he addressed the Piedmont Section, the South Central Section and the South-Eastern Section of the association, and visited a number of the textile enterprises.

THE twenty-fifth semi-annual meeting of the American Institute of Chemical Engineers was held in Chicago, from June 14 to 16. As reported in *Industrial and Engineering Chemistry* some two hundred and thirty members and guests were in attendance. The program consisted of a Symposium on "High-Pressure Technic," and another on "Measurement and Control in Chemical Industries," in addition to a group of general papers and a round-table conference devoted to the mathematical treatment of certain problems in the process industries.

THE organization meeting of The Society for Research on Meteorites will, through the courtesy of Director S. C. Simms and Dr. O. C. Farrington, be held in the lecture hall of the Field Museum of Natural History, Chicago, on Monday morning, August 21. All persons who have joined the society as

charter members and others who would like to become charter members at that time are cordially invited to attend. Persons interested in the purposes or activities of the society, as well as friends of members, will be welcome.

THE Buckston Browne Surgical Research Farm at Down, Kent, was formally opened by Sir Holburt Waring, president of the Royal College of Surgeons of England, on July 12.

A STRIP of countryside running for thirteen miles along the Palisades has been given by Mr. John D. Rockefeller, Jr., to become a part of the public domain if the commissioners of the Palisades Interstate Park can raise funds to develop it as a parkway "within a reasonable time." In announcing that he had offered the land to the commissioners, Mr. Rockefeller made public a letter to them in which he expressed the hope that, if the property were accepted, a treaty might be arranged between the States of New York and New Jersey for a joint commission "which would insure for all time a continuity and permanence of interstate administration" for the area. The property, which runs from about 2,500 feet south of the George Washington Bridge and extends north to the New York-New Jersey line, includes about 265 acres and was said to be worth about $5,000,000. Mr. J. Du Pratt White, president of the commissioners, in accepting Mr. Rockefeller's offer, announced that they would apply for a grant of $3,500,000 from the federal administration's public works program to pay for labor and materials for constructing the parkway. Provided the application is granted, work could be started within 60 days.

AN Associated Press dispatch reports that August 1 has been set as the date for closing twenty-three Weather Bureau observation stations in seventeen states as part of the effort of the Department of Agriculture to cut expenditures this year. Observers in all cases will either be retired or transferred.

THE publication of a thirteenth edition of the American Medical Directory was authorized at the recent meeting of the American Medical Association.

BEGINNING in January, 1934, the *Journal of Nutrition* will be published by the Wistar Institute, Philadelphia, instead of by the American Institute of Nutrition.

AN Institute of Public Health in Calcutta, a gift of the Rockefeller Foundation to the Government of India, was opened recently. It will be operated in cooperation with the Calcutta School of Tropical Medicine, where basic subjects will continue to be taught, while the institute deals with public health subjects. It will later be affiliated with the University of Calcutta, through which a doctorate in public health will be offered. The building, which harmonizes with the School of Tropical Medicine, has four stories, with facilities for teaching, laboratory work and lectures.

THE Carnegie Corporation, through the Carnegie Institution of Washington, has made a grant of $2,100 as emergency aid to the Institute of Forest Genetics at Placerville, California.

THE will of the late Mrs. Gertrude Dunn Hicks, leaving $479,000 to the University of Chicago, has been admitted to probate.

The British Medical Journal states that the annual report of the board of the British Institute of Physics shows that the many activities of the institute have continued to prosper and that the *Journal of Scientific Instruments* has made satisfactory progress. A new feature introduced during the year was the inclusion of articles specially written by authorities in their subjects, dealing with the trend of development of various classes of instruments and with matters of general interest to manufacturers. The opening in May of the joint library and reading rooms by the president, Lord Rutherford, marked an important step forward. Its establishment is the result of the work of the Joint Library Committee originally set up by the Institute of Physics, the Physical Society of London and the Optical Society.

AN exchange of art treasures by the Fogg Art Museum of Harvard University and the Spanish Government has been announced by the directors of the museum in Cambridge. The transfer restores to the Republic of Spain the Sahagun Tomb, said to be the most ancient sculptured sepulcher of the Middle Age period in Europe. Long sought by the National Archeological Museum of Spain because of its historical significance, the tomb was finally found in America in the possession of the Fogg Art Museum. In gratitude for this act, the Spanish authorities are presenting to Harvard a collection of objects of artistic and archeological value.

ACCORDING to the *Journal* of the American Medical Association, a society for encouraging the promotion of all branches of science in Japan was formally organized this spring. The last session of the diet approved the government's annual subsidy of 750,000 yen. The emperor's subsidy was 1,500,000 yen. The total sum to be spent annually to encourage scientific research will amount to 5,000,000 yen. The honorary president of the society is Prince Chichibu, the younger brother of the emperor; the president is Viscount Admiral Saito, the prime minister, and the chief director is Dr. Joji Sakurai, president of the Imperial Academy. From medical circles, six coun-

cilors were appointed, including Dr. T. Kitajima, head of the Japan Medical Association. The society will begin work this autumn; its selection is said to be the result of careful deliberation by 110 councilors.

DISCUSSION

OBSERVATION OF A NEW MEXICO METEOR FROM THE AIR

A METEOR of unusual size and brilliancy passed over a portion of the Texas Panhandle and eastern New Mexico on the morning of March 24, 1933. This meteor was described in *Science News Letter* for April 8, by Dr. John Strong, of the California Institute of Technology, who observed it from a train between Springer and Wagon Mound, New Mexico.

A rare opportunity for observing this meteor was had by C. W. Coyle, a T. and W. A. air pilot flying from Albuquerque, New Mexico, to Amarillo, Texas. Mr. Coyle was in the neighborhood of Adrian, Texas. When first seen by him the meteor was very low; it seemed to be rising in the east and appeared like a floodlight gradually being turned on. Then it seemed to be coming directly toward him, rapidly increasing in brilliancy and leaving a long trail behind.

The meteor passed to the north of his line of flight, and as it passed him, fragments were discharged from the meteor. It seemed to disappear in the longitude of Tucumcari, New Mexico, perhaps in the vicinity of Mosquero. In passing, the meteor seemed to be lower than the airplane, which was flying at an elevation of about 7,000 feet. The direction of the trajectory was judged to be about 70 degrees west of south.

The time of the meteor's flight was about 5:07 A. M. (M. S. T.), and its duration was about 5 seconds. The illumination caused by the meteor is described as "three times as light as day." (The hour was a little before sunrise.) The front of the meteor was a reddish color and behind it was a cone of blue. The "tail" was a bluish, incandescent cloud, which continued visible, through several changes of color and form, until dawn, or till 5:35 A. M. This cloud of meteoric dust was visible at Amarillo through a low fog or haze, and was at an elevation of about 50 degrees with the horizon.

The passing of the meteor created an electrical effect, which appeared in the radio set of the pilot, resembling frictional static sometimes caused by dust in the air. This effect lasted for a little while after the meteor had passed.

Sounds were reported, as coming from the meteor, at Clayton and Estancia, New Mexico, and Texline, Texas.

The meteor was noticed by an air pilot, Mr. Frank Williams, who was flying west near the Zuni Mountains, about 300 miles west of the other air pilot. He saw the light of the meteor and the cloud which hung in the sky, but the meteor did not pass him. He noticed that the bright light ended suddenly.

An observer at Amarillo, Texas, saw the meteor first at an elevation of about 50 degrees and almost directly northeast of him. He observed it for some seconds, as it seemed to come directly toward him, growing brighter rather than seeming to move. He noticed that the light was bluish at first, but in passing was like the sun. He saw the cloud for 30 minutes, but there was no cloud caused by the explosion. He saw the meteor "explode," he thought near Clayton, New Mexico. He noticed that most of the fragments seemed to "shoot up" and then disappear; only a few, and larger, pieces fell down and backwards.

An Associated Press notice of May 8 stated that a man living near Vanadium, New Mexico, exhibited at Silver City a 400-pound meteor which he had dug up on his ranch at a depth of 18 feet. He reported having been awakened on the morning of March 24 by a loud explosion and quaking of the earth. If this was a piece of the same meteor that was seen in the northeastern part of the state, its position would indicate that it had been shot out at the time of the explosion of the meteor, following a somewhat different direction from that of the original meteor.

One of the most remarkable records of the meteor is a photograph of the cloud of meteoric dust, that was taken by an Albuquerque photographer about 20 minutes after the passage of the meteor. This shows a very luminous area beyond dark clouds overhanging the Sandia Mountains 15 miles to the northeast. The sky shows just a little illumination at the right of the picture, due to the approaching dawn.

R. W. ELLIS

UNIVERSITY OF NEW MEXICO

AN EXPLANATION OF THE CAUSE OF SPIRAL GRAIN IN TREES

SPIRAL grain in so-called twisted trees has engaged the attention of several observers from widely separated parts of the country. Seifriz[1] has reviewed the literature relative to spiral grain and presents an interpretation of the cause.

Eames and McDaniels[2] state (p. 145) that "spiral grain also is related to the structure of the cambium." Division of the cambium by a peculiar kind of cell-plate formation has been decsribed by Bailey.[3] Spiral

[1] William Seifriz, SCIENCE (n.s.), 77: 50–51, 1933.
[2] A. J. Eames, L. J. McDaniels, "Introduction to Plant Anatomy," McGraw-Hill. 1925.
[3] I. W. Bailey, *Amer. Jour. Bot.*, 7: 417–434, 1920.

grain depends for the most part upon division of the cambium and the events that follow. When the cambium divides tangentially, xylem or phloem will be formed from the resulting daughter cells. Circumferential increase of the cambium is accomplished by radial (anticlinal) division; by oblique radial division; or, by oblique transverse division followed by increase in size and accompanied by gliding growth; and, by division of cambium initials to form new ray initials (Bailey).[4] It is in the non-stratified type of cambium, as reported by Bailey, that the oblique transverse wall is more commonly formed. Practically all trees reported to have spiral grain possess this type of cambium. The vertical growth of a tree comes about from activity of apical meristems, while very little or no vertical increase occurs at the base of the tree. Radial increase of the tree follows upon cambial activity, with yearly increments of xylem and phloem. Radial division of the cambium is found less frequently in tangential sections than tangential division, as well as oblique transverse division, which may immediately follow radial division. Fig. 1, accompanying this article, was made from a photomicrograph of a tangential section of cambium cut in celloidin, in which division occurred (1) by a radial cell plate; and (2) transversely by an oblique cell plate. The cell plates which subdivide the mother cell into four daughter cells show no pits. What is the future of these daughter cells? We are faced with the fact that the daughter cells in their vertical increase must be given some space in some way, whether or not we accept it as a manifestation of gliding growth. The oblique transverse wall seems to determine the pitch of the path they take in elongation, since they are held in a sort of straight jacket, which prevents true perpendicular elongation. This path of elongation is diagonally around the tree, or spiral, since it is a path of least resistance. After maturation of the daughter cells has occurred, further divisions are tangential, which causes radial increase. The resulting xylem mother cells and their daughter cells, as well as phloem mother cells and their daughter cells, upon maturation follow in the path of the spirally directed cambium initials. As this process continues from year to year with a further radial enlargement of the stem, the spiral path deviates more from the perpendicular and approaches a closer spiral. However, if the oblique transverse wall changes about and starts a path in the opposite direction, the tier of xylem and phloem which follows upon it balances the spiral in the opposite direction, and no spiral grain is apparent. The present writer appreciates an element of uncertainty in this apparently plausible explanation of the cause of spiral grain in trees.

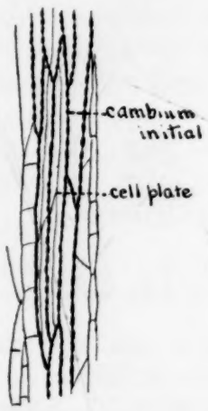

Fig. 1

Knorr[5] suspected that "intensity of the twist" was more pronounced in the later wood of branches, while Herrick[6] observed that pitch of the spiral grain increased with age of the tree, and figures to demonstrate this are recorded. These observations would seem to substantiate somewhat the above explanation. Seifriz[7] interprets spiral grain as a phenomenon based partly on heritable protoplasmic qualities and in part on physiological factors. It is a matter of great uncertainty, whether the cause of the formation of an oblique transverse wall could be attributed to the Liesegang phenomenon. Moreover, the seemingly wide-spread spiral tendency among many plants and animals, which Seifriz believes to be of protoplasmic origin, seems rather remote in its relation to the causal factors of spiral grain. The spiral tendency in trees is fortuitous, but it would seem a natural assumption that parent spiral-grain trees and their progeny should show variations such as occur in all offspring. Consequently, clockwise, counter clockwise and straight grain trees should be expected in any stand of timber trees.

EDWIN J. KOHL

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THE POISONING OF FISH

IN the construction of an artificial lake in Davis County, Iowa, for the Fish and Game Commission, it seemed advisable to destroy the detrimental and infected fish which occupied the creek running through it. The fish deemed undesirable were the black bullhead (*Ameiurus melas*), a runt, the black-striped shiner (*Notropis dorsalis*), and the green sunfish (*Apomotis cyanellus*), the two latter heavily infested with trematode larvae. Carp and gar may also have been present.

On account of the character of the creek bed, sein-

[4] I. W. Bailey, *Amer. Jour. Bot.*, 10: 499–509, 1923.

[5] F. Knorr, *Jour. Heredity*, 23: 49–52, 1932.

[6] E. H. Herrick, SCIENCE (n.s.), 76: 406–407, 1932.

[7] William Seifriz, *loc. cit.*

ing was impractical. It was therefore necessary to find a safe and economical method of poisoning the fish. Since the literature on this subject seems to be quite meager, it is felt that a short note on our experiments might prove helpful to others who may have the same problem.

A solution of copper sulfate in the concentration of 8 pounds per million gallons of water was first tried. Whipple[1] states, in part, that carp are killed in a solution of 2.8 pounds of copper sulfate per million gallons of water, and catfish in 35 pounds of copper sulfate per million gallons of water. In our experiment, we began at the upper end of the stream and constructed a series of small dams, making a number of pools in which the concentration of copper sulfate could be fairly accurately estimated.

In the first of these pools a solution of 8 pounds of copper sulfate per million gallons of water was used. At the end of 55 minutes no fish seemed to be affected. The concentration was then increased up to 7,500 pounds per million gallons; still no lethal effects were observed even after three hours, nor did the fish seem distressed. In other pools where the same dosages were used no dead fish were found after 48 hours of exposure to the solution.

Chlorinated lime with a chloric content of 24 per cent. was next used. In a solution of 1 pound per 2,000 gallons of water, fish were killed in twenty minutes. In quiet water, a solution of chlorinated lime in the ratio of 1 pound per 5,000 gallons of water was effective, but after a longer time. In the running water, a solution of 1 pound per 2,000 gallons of water affected the fish after 10 minutes' exposure, and at the end of 20 minutes respiratory movements ceased. In still waters, a weaker solution was slower in action, but at the end of 48 hours practically all the fish were in a dying condition.

Our experiments show that in out-of-door conditions copper sulfate, even in high concentrations, proved ineffective, while a chlorinated lime solution of 1 pound per 2,000 gallons of water concentration killed the fish tested in 20 minutes or less.

WALTER W. AITKEN
IOWA FISH AND GAME COMMISSION

PUNISHMENT AND REWARD IN LEARNING

IN a recent article in SCIENCE[1] and in other papers,[2] Thorndike has called attention to the apparently anomalous influence of punishment on learning. He reports that when punishment follows an act, the underlying connection, instead of being weakened, is either unaffected or strengthened. This is contrary to expectation and to the results of other studies. Thorndike attaches great significance to these results, suggesting that from the psychological point of view, punishment is not the opposite of reward.[3] Thorndike and, later, Lorge[4] suggest that in such cases the connection derives enough strength from just functioning to offset the potential weakening influence of punishment.

It should be pointed out that in Thorndike's experiments and in this discussion "punishment" means merely telling the subject that he has made a wrong choice.

In a series of experiments[5] I find that the weakening influence of punishment is also offset by the strengthening influence of the medium which carries both punishment and reward. To inform a subject that he is right or wrong one must use some physical medium, such as sound or flashes of lights, or the like. I find that the application of the medium itself, (*e.g.*, when it is divorced from all information as to success or failure) has a definite strengthening influence. When the medium is made to carry information of failure, its strengthening influence is reduced, and when it indicates success, its strengthening influence is increased.

The various extents to which a bond is strengthened by the application of different conditions is illustrated graphically below.

Here O represents the extent to which a bond is strengthened when the associated act is followed by nothing whatever, M the amount of strengthening due to the application of the *medium alone,* M+P the amount of strengthening due to the application of the *medium conveying punishment,* and M+R the amount due to the application of the *medium conveying reward.*

From the above illustration it will be seen that with reference to O the gross influences of M+P and of M+R are in the same direction but of different extents, but that with reference to M the net influences of P and R are in opposite directions and may be of equal extent. That is to say, that when punishment and reward are corrected for the influence of the conveying medium they may (in these experiments) be considered as psychological opposites.

J. M. STEPHENS
THE JOHNS HOPKINS UNIVERSITY

[1] "The Microscopy of Drinking Water," 4th ed., 392, table 94, 1927.

[1] SCIENCE, 77: 173, February 10, 1933.

[2] "The Fundamentals of Learning," 1932; "Human Learning," 1931; "Comparative Psychology Monographs," 1931–32, 8, no. 4.

[3] "The Fundamentals of Learning," p. 313.

[4] *Jour. Exper. Psychol.*, 16, 177–207, 1933.

[5] The details of this series will appear in a future issue of the *Journal of Experimental Psychology.*

QUOTATIONS

SCIENCE AND PUBLIC WORKS

THE economy axe has been wielded with so much zeal, not always according to knowledge, among government bureaus that science has fared badly. Even in prosperous years less than 1 per cent. of the federal budget was appropriated for research. Now there is a reduction of 60 per cent. over 1932. The army and navy, on the other hand, will continue to receive huge sums. So glaring is the discrepancy that various cabinet members have done their best to correct a manifest error of judgment.

The term "public works" is so broad that it can be made to embrace not only such tangible structures as roads, bridges and radio stations, but also the testing of airplane engines in a laboratory that must now stand idle, or the discovery of new alloys. Reasoning thus, Secretary of Commerce Roper applied for grants out of the public works fund to continue research that had to be abandoned. On behalf of the Bureau of Standards, which has been compelled to rid itself of 380 of a staff that once numbered 974, he asked for no more than $450,000. There were also requests to aid the Bureau of Mines ($275,000), the Bureau of Fisheries ($1,072,474), the Coast and Geodetic Survey ($3,300,938) and the Bureau of Lighthouses ($2,355,068), the money to be spent on "new projects." Since buildings and equipments are public property, further applications were made for funds to recondition them. Secretary Ickes appealed for aid to permit the Geological Survey to continue investigations of the highest importance to the mineral industries, and Secretary Wallace stepped into the breach on behalf of the Department of Agriculture.

The first decisions on these applications have now been made. They make sad reading for science. Of the $64,561,542 of the public works funds involved, only $4,255,592 is to be spent by scientific bureaus, and this largely for labor and building material in making necessary repairs. Evidently the term "public works" is narrowly construed. Between public works in the strict sense of the term and laboratory research the choice should be easy. The record of such an institution as the Bureau of Standards speaks for itself. Literally tens of millions have been earned and a score of new industries have been created by research. Besides, there is the question of hundreds of highly trained chemists, physicists and engineers. Are they now to be numbered among the unemployed? They have been the most powerful of all creators of employment. A million entrusted to them returned not only tens of millions but gave us industries of which there was no previous inkling.—*The New York Times.*

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A PHOTOGRAPHIC TECHNIQUE FOR THE STUDY OF EXTENSIVE DATA ON SMALL POPULATIONS[1]

A METHOD which would facilitate the study of interrelationships among extensive clinical observations, physiological measures and test results was required for the investigation of reaction tendencies in psychopathic cases. In order that significant and suggestive interrelationships might be determined without too great expenditure of time and energy, we adopted a procedure which seems applicable in many fields of investigation where there are a great many data on, let us say, less than a hundred cases. Briefly, the method is to copy all data in tables on large sheets of draughtsman's tracing cloth, to cut the table into strips, one strip for each case, to arrange the strips according to any desired grouping or ranking in a printing frame, to blue-print the table thus arranged, and then to search the blue-printed table for measures differentiated by the grouping or ranking.

More specifically, it has been found practicable to list the names of the various measures on which data are available in a wide strip along the top of the table as a universal heading. The individual cases are listed at quarter inch intervals in a column at the left, and the data for each case are transferred to the row opposite the case name in the appropriate data columns. Holes are punched at a uniform distance from the two ends of each row of data before cutting the table into strips. A printing frame is constructed slightly larger than the table, with a row of small nails spaced at quarter-inch intervals on each side. The holes in the left end of the strips fit the nails along the left edge of the frame. A rubber band fastened through the hole in the right-hand end of each strip maintains a moderate tension when it is looped over an appropriate nail at the right of the frame. One of the rows of nails may be in a detachable section of the frame, so as to permit lifting the arranged strips for the insertion of a sheet of

[1] Report from the Behavior Research Fund and the Institute for Juvenile Research, Chicago, Series B, No. 192.

blue-print paper. A glass plate may be used to maintain a good contact between the strips and the sensitive paper. Thirty to ninety seconds exposure in sunlight is sufficient for medium speed blue-print paper. The sheets may be fixed by washing under running tap water. When purchased in fifty yard rolls, the blue-print paper for tables of convenient size, two or three feet by three feet, costs about five cents per table.

Any number of tables representing any groupings or any rankings of the data which are desired may be made with no more work than is required for a rearrangement of the strips. Groupings of the data may be conveniently separated by a white band on the printed table by placing an opaque strip in the frame between the groups. An inspection or an average of the groups in the columns under the various headings will often be sufficient to determine whether a relationship is worthy of further study.

If it is desired to study the data with regard to two different dimensions, they may be ranked according to the chosen variables, divided into appropriate groups, blue-printed, and the various columns of data cut and pasted on separate sheets to show the distribution of any desired third variable with respect to x and y.

CHESTER W. DARROW
BEHAVIOR RESEARCH FUND, AND THE
INSTITUTE FOR JUVENILE RESEARCH
CHICAGO, ILLINOIS

AN IMPROVED CAPILLARY MERCURY VAPOR LAMP

THE capillary mercury vapor lamp designed by Daniels and Heidt[1] has been extensively used in some radiation studies. With this use of the lamp we have introduced several changes in construction which have made it more practical and have extended its usefulness.

Instead of using quartz tubing of uniform diameter throughout, the part of the lamp above the upper pair of bulbs is made of tubing of inside diameter 0.5 mm larger than that of the remainder of the lamp. Through this capillary of larger diameter is introduced a short piece of graphite (fired pencil lead). Otherwise the lamp is arranged in the usual manner. In the completed lamp the graphite is caused, by slight tapping, to come to rest at the point where the capillary of smaller diameter begins, that is, at the base of the lower bulb of the upper pair. The piece of graphite now blocks the capillary and is in contact with the mercury column above and below. When the current is passed through the lamp the graphite, because of its high resistance, becomes very hot. Some of the mercury vaporizes and the arc starts immediately. By following the above procedure the lamp may be started as many times as desired.

The advantages of this self-starting lamp are: (1) the awkward procedure of starting the lamp with a flame or heater is avoided; (2) the lamp is started under water and is constant immediately; (3) breakage of lamps due to the sudden cooling of the exterior by water when they are started by the older methods is largely avoided; (4) when light of wave-length longer than 3100 Å is desired materials other than quartz may be used. It was found possible to use lamps constructed with special glass, thus cutting their cost to a few cents each.

It has also been practicable to fill these lamps with amalgams (Hg + Cd, Hg + Zn, etc.) of such composition that they can be used repeatedly without breakage. These amalgams supply light of wave-lengths not present in the mercury spectrum.

ALEXANDER HOLLAENDER
J. F. STAUFFER
UNIVERSITY OF WISCONSIN

SPECIAL ARTICLES

INVESTIGATIONS IN PUERTO RICO ON MANSON'S BLOOD-FLUKE INFECTION (SCHISTOSOMIASIS MANSONI)

AN intensive study of *Schistosoma mansoni* infection in Puerto Rico is being undertaken this summer by cooperative efforts of the School of Tropical Medicine of the University of Puerto Rico under the auspices of Columbia University and the Department of Tropical Medicine of Tulane University. The investigation has been made possible by grants from the Bailey K. Ashford Fund and the National Research Council.

Schistosoma mansoni is a unisexual blood-fluke living in the portal vessels of its host, usually man. It produces dysentery and later fibrous and papillomatous modifications of the intestinal tract and cirrhosis of the liver. The female worms lay large lateral-spined eggs into the mesenteric and rectal vessels, so that the majority of these eggs work their way through into the intestinal lumen and are passed in the feces. In water the eggs hatch and the emergent larva (*miracidium*) attacks and penetrates the soft tissues of the appropriate snail (species of *Planorbis*), in the "liver gland" of which a twofold

[1] Farrington Daniels and L. J. Heidt, *Jour. Amer. Chem. Soc.*, 54: 2381–2384, 1932.

multiplication takes place. After several weeks a swarm of fork-tailed *cercariae* emerge from the snail, swim about in the water and in case mammalian species enter this "infected water," the cercariae adhere to the skin of the mammal, drop their tails, penetrate through the skin and by way of the afferent and systemic circulation eventually reach the portal system, where they develop into male and female worms.

This infection, which is relatively common in parts of Africa, particularly in the Nile Valley, was brought to the New World with the importation of slaves and became established in Brazil, Venezuela and the Guianas. It has also been reported from Peru, Panama and Costa Rica, although it has probably not become established in the latter two countries. It is known to be present in the Lesser Antilles, especially in Antigua, Guadeloupe, St. Kitts, Martinique and Barbadoes. It also occurs in Puerto Rico, where it was first reported by Gonzalez-Martinez in 1904, three years before the species was differentiated from *Schistosoma haematobium* (the vesical blood-fluke), with which it is frequently coextensive in Africa. No autochthonous case of *S. mansoni* infection is known for North America.

In view of the limited size of the Island of Puerto Rico, and because of the economic importance of the disease on the island, a unique opportunity is afforded for study of the infection.

Important preliminary studies on the epidemiology, biology, pathology and clinical aspects of the disease have been made by members of the staff of the School of Tropical Medicine at San Juan. The present investigation will be confined to the following program:

Biological Aspects

(1) Ways by which the viable eggs reach the waterways where the intermediate host lives.

(2) Hatching phenomena and infection of the snail. (An abundance of viable eggs is needed to determine experimentally if species of *Planorbis* in the United States can be readily infected).

(3) Length of time required for complete development in the appropriate snail, and period of discharge of viable cercariae from the snail.

(4) Route of migration of the young worm through the human body, once it has penetrated through the skin.

(5) Number of eggs in the uterus of the female worm.

(6) Method of deposition of eggs in the gut wall. Do eggs migrate in the tissues?

Pathological and Clinical Aspects

(1) Does schistosomiasis splenomegaly constitute an important clinical entity in Puerto Rico?

(2) Can splenomegaly and hepatic cirrhosis develop in experimental animals harboring only one sex of the worm (male or female)?

(3) Types of ulceration and papillomata developing in experimental animals (monkeys, rabbits, etc.).

(4) The reliability of precipitin and other serological tests as a means of diagnosis.

(5) Factors determining selection of mesenteric and rectal veins by worms.

Epidemiological Aspects

(1) How and in what locations do the people of Puerto Rico expose themselves to infections?

(2) Natural reservoir hosts of the infection in Puerto Rico. The types of canals and ponds where the snails abound and afford an opportunity for carrying on the life cycle.

(3) Determine the best method or methods for attacking the problem of prevention in Puerto Rico.

ERNEST CARROLL FAUST
TULANE UNIVERSITY OF LOUISIANA

TRANSMISSION OF INFECTIOUS EQUINE ENCEPHALOMYELITIS IN MAMMALS AND BIRDS

IN 1931, Meyer, Haring and Howitt[1] reported the recovery of a filtrable virus from the brain of a horse suffering from an acute form of encephalomyelitis which had been particularly prevalent among horses and mules of rural sections of California during the years 1930 and 1931. They have conducted extensive experiments with this and subsequently recovered strains of the virus and reported horses, mules, guinea pigs, monkeys, white rats, white mice and rabbits[2] as being susceptible to the infection. Guinea pigs have been found to be admirably adapted to the investigation of the experimental disease.

In 1932 the writers recovered a strain of encephalomyelitis virus from the brain of a field case which occurred in South Dakota where the disease was epizootic. In the course of experimental work with this virus, calves (2), sheep (2), dogs (4) and cats (2) have been tested for evidence of susceptibility to intracerebral inoculation. In these preliminary trials, the three last named species have been found to be definitely refractory.

The inoculated calves developed a febrile reaction which persisted for several days. Five days following inoculation of a 0.5 cc dose of encephalomyelitic guinea pig brain emulsified 1 part in 10 parts (approximate) of physiological saline, both animals displayed anorexia, difficult swallowing, stupor, incoordination, grinding of the teeth, localized myopalmus and photophobia. The intensity of these symptoms

[1] K. F. Meyer, C. M. Haring, B. Howitt, "Etiology of Epizootic Encephalomyelitis of Horses in the San Joaquin Valley," SCIENCE, n. s., 74: 227–8, 1930.

[2] K. F. Meyer, C. M. Haring, B. Howitt, "Newer Knowledge of the Neurotropic Virus Infections of the Horse," *J. A. V. M. A.*, n. s., 32: 3, 1931.

in each case varied during the succeeding days and the general attitude varied from extreme lassitude and drowsiness on the one hand to hyperesthesia and clonic spasms on the other. The height of the clinical reaction occurred on the 7th to 9th days, retrogressing to normalcy on the 14th day with the animals remaining normal on the 20th day.

Using a very active sample of the same virus, White Leghorn cockerels (3) about 4 months of age and mature common pigeons (4) were inoculated intracerebrally while under light chloroform anesthesia. A 0.2 cc dose of approximately a 1/50 dilution of virulent guinea pig brain was used. The cockerels have remained normal for 20 days.

The four pigeons so inoculated developed general weakness, ataxia and marked tremors on the third day; dying on the third to fourth day after inoculation. The brains of these pigeons produced the typical disease in guinea pigs. Pigeons receiving normal guinea pig brain were in no way affected by the inoculation.

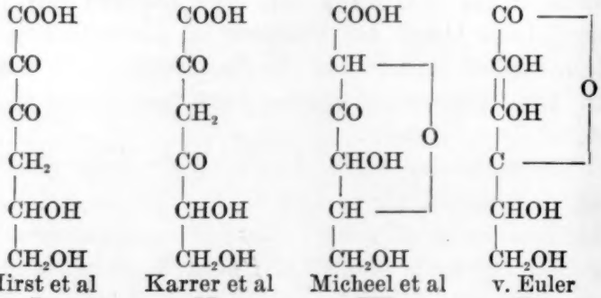
These inoculations, though too limited for final conclusions, indicate that calves are not entirely refractory to encephalomyelitis. A 100 per cent. "take" in the case of pigeons indicates the possible use of these birds in routine examination of tissues from field cases. The possible relationship of the calf and the pigeon to the epizootiology of the natural disease is worthy of consideration.

L. T. GILTNER
M. S. SHAHAN

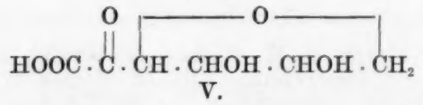
BUREAU OF ANIMAL INDUSTRY
U. S. DEPARTMENT OF AGRICULTURE

PRELIMINARY NOTE ON THE STRUCTURE OF ASCORBIC ACID (VITAMIN C)

THE following formulae have been advanced to express the structure of ascorbic acid:



And a fifth possible one may be suggested:



V.

It should be possible to choose the correct expression for the structure of ascorbic acid on the basis of the results of hydrogenation. Structures I and II require four atoms of hydrogen for complete reduction, and the rest only two atoms. The hydrogenated products thus obtained should differ in the number of hydroxyl groups, I and II having four, III and V three, and IV five.

Structures I and II may be differentiated by the ability of the reduction product of II to form a γ lactone, while that of I can not. Likewise, the reduction products of III and V may be differentiated by the ability of that of V to form a lactone, whereas that of III should not, inasmuch as the known 2, 5-anhydrohexonic acids do not form lactones.

On the basis of these considerations, ascorbic acid was exhaustively hydrogenated. Only two atoms of hydrogen were absorbed, and the resulting acid formed a stable lactone. In order to ascertain the number of hydroxyl groups, the product was acetylated, but unfortunately, the acetyl derivative could not be crystallized. The analysis of the amorphous product did not permit a definite conclusion as to the number of hydroxyl groups, inasmuch as the various possible acetyl derivatives do not present sufficiently striking differences in elementary composition. It is hoped, however, that methylation of the hydrogenated ascorbic acid will afford accurate information as to the number of hydroxyl groups present. The experiments will be performed as soon as the necessary material is available.

The present indications would seem to favor IV or V as the probable structure of the ascorbic acid.

The material for the present experiments was generously placed at our disposal by Professor Szent-Györgyi, to whom we wish to express our great indebtedness.

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